

PH2

Question			Marking details	Marks Available
1	(a)		0.40 [m]	1
	(b)		$v = \frac{0.050}{0.10}, \frac{0.450}{0.10}$ etc or $\left(\frac{1}{0.8}\right) \times 0.4$ or by implication (1)	2
			$v = 0.50, 4.5$ etc [m s ⁻¹] (1)	
	(c)		1.25 Hz UNIT MARK [ecf on v and λ and T]	1
	(d)		same	1
(e)		B lags A (1)		
			by $\frac{1}{4}$ cycle / 90° / $\frac{\pi}{2}$ accept $\frac{T}{4}$ or $\frac{\lambda}{4}$ (1)	2
Question 1 total				[7]
2	(a)		Direction of wave [or energy] travel and direction of [particle] displacements [or oscillations] are the same [or parallel].	1
	(b)	(i)	diffraction	1
		(ii)	No zeros (or waves spread right round) so $\lambda \geq 0.3$ m (1) $\lambda = 0.9$ m for 375 Hz or $\lambda = 0.09$ m for 3 750 Hz or if $\lambda = 0.3$ m then $f = 1\ 100$ Hz (1) 375 Hz more likely with some supporting argument, e.g. the above, or even just “Longer wavelengths [or lower frequencies] spread more.” (1)	3
(c)		$\lambda = 140$ [mm] (1) Any 2 x (1): Interference occurs between [accept superposition of] waves travelling in opposite directions [accept waves from speaker and reflected waves] Board acts as reflector Stationary wave set up	3	
Question 2 total				[8]

Question			Marking details	Marks Available	
3	(a)	(i)	Same point in cycle at same time or equivalent	1	
		(ii)	$S_2P - S_1P$ or equivalent. [Accept $S_1P - S_2P$]	1	
		(iii)	(I)	Path difference = 36 mm (1) which is 3λ , so constructive. (1) Award 1 mark only for : $S_1Q = 28\lambda$, $S_2Q = 25\lambda$ therefore arrive in phase so constructive interference	2
			(II)	[Path difference doesn't change], so always constructive (1) but signal strength will decrease as we move further from sources. (1)	2
	(iv)	$y = \frac{12 \times 360}{36}$ even if units inhomogeneous (1) $y = 120$ mm UNIT (1)	2		
(b)		correct insertion of 12 [mm] and 30 [mm] into grating equation or by implication (1) 24° (1) 53° (1) award 1 mark if both angles wrong because of arithmetic error Either 0° or $\pm 24^\circ$ and $\pm 53^\circ$ or equivalent. (1)	4		
Question 3 total				[12]	
4	(a)	(i)	incident ray and angle c marked and grazing refracted ray	1	
		(ii)	$n_1 \sin c = n_2 \sin 90^\circ$ (1) $\sin 90^\circ = 1$ or $n_1 \sin c = n_2$ (1)	2	
	(b)	(i)	$\sin c = \frac{x}{s}$ and c marked on diagram (1) convincing algebra (1)	2	
		(ii)	$v = 2.0 \times 10^8 \text{ ms}^{-1}$ [or by implication] (1) $t = 6.00 \mu\text{s}$ [or $t = 4.00 \mu\text{s}$, in which case first mark not gained] (1)	2	
		(iii)	time via zigzag = $6.00 \mu\text{s} \times \frac{1.500}{1.485}$ [= 6.06 μs] or $\frac{1212}{2 \times 10^8}$ (1) [ecf on $t = 6.00 \mu\text{s}$ or by implication] $\Delta t = 0.06 \mu\text{s}$ [ecf on 6.00 μs] (1)	2	
		(iv)	$[\frac{1}{6.00 \times 10^{-6}}] = 17 \times 10^6 \text{ [s}^{-1}]$ [Accept $(18 \pm 2) \times 10^6$] (1) assumes negligible pulse duration [or assumes angles of incidence range from 0 to c or longest path is 1 212 m] (1)	2	
		Question 4 Total			

Question			Marking details	Marks Available	
5	(a)	(i)	[minimum] energy needed to eject an electron from the metal [or surface or solid not atom]	1	
		(ii)	6.9×10^{14} [Hz]	1	
		(iii)	Photon energy not high enough [$<$ work function] (1) Electrons can't escape (1)	2	
	(b)	$f = \frac{(E_{k\max} + \phi)}{h}$ or correct transposition at any stage or by implic(1) $= 1.0 \times 10^{15}$ [Hz] (1)	2		
	(c)	(i)	3.2×10^{-19} [J] (1) This uses the higher energy [or the higher frequency] photons, or produces the higher energy electrons, or photons don't co-operate or equivalent (1)	2	
		(ii)	2.0 [V] ecf	1	
Question 5 Total				[9]	
6	(a)	(i)	$\lambda = \frac{hc}{\Delta E}$ or [$\lambda = \frac{c}{f}$ and $E = hf$] or $f = 2.8 \times 10^{14}$ [Hz] (1) $\lambda = 1.06 \times 10^{-6}$ [m] (1)	2	
		(ii)	<i>up</i> arrow from L to U (1) Photon's energy given to atom or electron (1)	2	
		(iii)	(I)	[Incident] photon causes electron to drop from U to L. (1) Incident photon must have energy $E_U - E_L$ or equivalent (1) Photon emitted so now 2 photons present; accept by implic from emitted photon in phase.(1)	3
			(II)	Need more electrons in U than L. <i>Accept</i> : need pop'n inversion (1) Electrons pumped to P and drop to U (1) Electrons drop from L to ground [helping to keep L depopulated].(1)	3
	(b)	Any 2 x (1): monochromatic [or equivalent e.g. long wave-trains] photons in phase (don't accept waves in phase) light in phase (or wavefronts continuous) across width of beam	2		
Question 6 Total				[12]	

Question			Marking details	Mark Available
7	(a)	(i)	$\lambda_{\text{peak}} = 430 \text{ n[m]} [\pm 10 \text{ nm}] \quad (1)$ $T = 6700 \text{ [K]} \text{ ecf on } \lambda_{\text{peak}}, \text{ provided it's not } 1200 \text{ nm} \quad (1)$	2
		(ii)	$T = 5400 \text{ [K]} [\pm 250 \text{ K}]$	1
		(iii)	bluer or whiter at maximum T or redder at minimum T	1
	(b)	$A = \frac{P}{\sigma T^4}$ (transposition at any stage) or by implication (1) $A = \frac{1.46 \times 10^{30}}{5.76 \times 10^{-8} \times 6700^4} [= 1.3 \times 10^{22} \text{ m}^2] \text{ ecf on } T \quad (1)$ use of $A = 4\pi r^2$ or $A = \pi d^2 \quad (1)$ $d = 6.4 \times 10^{10} \text{ [m]} \text{ ecf on } T \text{ if value from (a)(i) used} \quad (1)$ Slips of factors of 2 or 10 lose 1 mark each.	4	
(c)	$\left(\frac{P_{\text{min}}}{P_{\text{max}}}\right) = \left(\frac{T_{\text{min}}}{T_{\text{max}}}\right)^4$ or $P_{\text{min}} = 6.2 \times 10^{29} \text{ W ecf} \quad (1)$ $\frac{P_{\text{min}}}{P_{\text{max}}} = 0.42 \text{ ecf} \quad \text{or} \quad P_{\text{max}} - P_{\text{min}} = 8.4 \times 10^{29} \text{ W ecf} \quad (1)$ $\left(\frac{P_{\text{max}} - P_{\text{min}}}{P_{\text{max}}}\right) = 0.58 \text{ [accept]} = 58\% \quad (1)$	3		
Question 7 Total				[11]
8	(a)		+2, 0 (1) ūd, -1, 0 (1) [blank], 0, 1 [Accept 'none' instead of cell left blank.] (1)	3
		(i)	Sun or stars	1
		(ii)	e-m and γ or photon involvement	1
	(iii)	In stage 1: 0 + 0 goes to 0 - 1 + 1 [or equivalent] (1) In stages 2 and 3, zeros throughout or equivalent (1)	2	
	(iv)	(I) uud + uud goes to uud + udd accept d: 2→3, u: 4→3 (1) A u is lost and a d is gained [or a u changes to a d]. (1) (II) Neither involves weak force or equivalent e.g. only strong [and em] force involved.	2 1	
Question 8 Total				[10]